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FOUR CATEGORIES OF SPECIES.

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THERE are at least four different sorts of species, so called, involved in the study of as many theoretically related, but also theoretically and practically distinct, taxonomic problems. The result of indiscriminately confusing these problems and their specific criteria has been the occasion of many destructive criticisms of systematic biology. Such objections are frequently valid, but not as uniformly pertinent, since they rest, in reality, on faulty analysis rather than upon any inextricable difficulties or logical inconsistencies connected with the several tasks of biological taxonomy.

To vary somewhat the familiar comparison of organic nature to a tree and its branches, evolutionary theories permit us to think of life rather as originating at a point which, by the accretion of countless successive individuals, has become the center of a sphere upon whose surface existing vitality appears as islands in the sea of nonexistence. The section of such a sphere would differ from that of the earth in that the oceans would have enormous depth, for the solid core would separate from near its center into numerous and repeated divisions.

It is perhaps conceivable that life might have reached variety and complexity without accompanying segregation into limited

groups of similar individuals, in which case all the circumferential possibilities of form and structure would have been realized, with a result comparable to a uniformly solid sphere. Arguments and phylogenies are often based on this assumption, that all organic types have been connected by intermediate forms; but there is no valid reason to suppose that more than very few of such theoretical possibilities have been projected into the actual; the oceans of our vital globe are not only deep, but are in overwhelming proportion to the space otherwise occupied. Segregation has everywhere accompanied differentiation in structure, and the forms which might have maintained connection between the various branches of life are not in most cases to be thought of as extinct; they have never come to expression, never existed.

Having been accustomed to consider organic types as forming connected series, those who have approached systematic biology from the paleontologic standpoint have been especially prone to overlook the distinctions which arise from the fact that all such series are, in fact, lineal, and that their successive members have always been separated by chasms of nonexistence, so to speak, from all except phylogenetically related forms. Moreover, the points of actual contact with these last are few and momentary if the extent of biological history be taken into account; a grave fallacy is accordingly involved in the theory of classification which attempts to render nature at large comprehensible through methods logically applicable only to phylogenetic series. From the practical standpoint it is as though topographic expedients were limited to the numbering of houses. As such designations are of no utility unless streets are also known, so is the lineal method of classification of use only in dealing with ascertained series. Notwithstanding the theories of interlacing phylogeny which some authors have propounded, it may be asserted with confidence that the analogy of streets and numbers has but a limited application in nature. There are no cross-thoroughfares; all the lines radiate in general from a center, and while they may sometimes become closely parallel, we have as yet no adequate evidence that under natural conditions they ever reunite after more than the briefest divergence.

The species of the paleontologist is, then, with reference to the other members of its line, an arbitrary division of a continuous series of gradually changing forms. The fact of established sequence will go far to prevent confusion, and the purposes of classification are served by such a knowledge of forms and characters as will make possible the reference of a given individual to its proper place in the series. Illogical procedure may be charged against any attempt at applying these concepts or methods outside of the lines of established, or at least suspected, phylogeny.

The termini of such of the paleontological series as have not become extinct are the subject-matter of the biology of to-day, in contradistinction to that of the past or the future. Returning to the former analogy, it may be insisted that as the accretions of the life of previous ages have been built up on distinct lines, so is existing life manifested in assemblages of similar individuals, which are obviously distinct collectively. The forms which would be required to connect them do not exist, and we shall make little true progress in the knowledge of organic nature until we abandon the attempt at arranging living organisms in continuous series. With rare exceptions their relationship must be traced through the more or less remote past. In one sense all life may be thus connected, and absolute lines between groups of specific or higher rank are forever impossible; but in another and equally important sense groups of living organisms may be looked upon as separate and independent, though collective, entities. The study of geography has not been abandoned because of the discovery that all land is connected by the ocean bottom, nor is the topography of a series of islands neglected because soundings prove that they are peaks of a submerged mountain range. No naturalist denies the existence of clearly defined and easily recognizable specific groups, but the difficulty experienced in attempting to resolve the more nebulous parts of nature has sometimes blurred the eyesight of the systematist. In some generic archipelagoes the specific islands stand out prominent and distinct, like the members of the Canary and Hawaiian groups; while in others they are painfully similar and are separated only by narrow,

shallow, and tortuous channels, like the Florida Keys. These last are, indeed, a cartographer's nightmare comparable to the species of *Aster* and *Sphagnum*. But whether the naturalist's theories help or hinder, his descriptive task will not be complete until the facts of nature have been recognized and recorded, until all the islands have been located and mapped. That this work is in a confused and backward state is partly due to the conceptual fallacy of species and genera, which has led us to attempt to map the islands without securely locating them by the designation and preservation of types.

To divide a continuous series of forms into "genera" and "species" is a thoroughly artificial process analogous to the marking of feet and inches on a measuring rod, and is one of the instances where the naturalist may be said to "make" the "species." The specific islands of living organisms are, however, not made, but discovered by the systematist, and located, not primarily with regard to their disposition in an ancestral series, but with reference to other separate groups. Whether a specific island is large or small, circular or irregular in shape, is not subject to our determination; and the naturalist who expects to apply throughout nature a general concept of species based on the "size" or "weight" of characters is about as well equipped for his work as a map-maker who should undertake to draw a chart of the Florida Keys without other tools than a circular die. With such an implement he could in a general way indicate the location of a few well-separated islands like the Canaries, but the other task is practically impossible.

Although chronologically the first, the problem of systematic paleontology, on account of the fragmentary nature of its material, must depend largely upon the results gained in the study of existing forms. Isolated fossils may be classified, for the sake of convenience, in so-called species and genera in a manner analogous to that used with living types; but when any approximation to a complete phylogenetic series can be made out, that method is no longer logically applicable. The chasms which separate species in the present do not interrupt the unbroken line of ancestry which stands below every existing type,

and to locate a particular point in a continuous series of this kind is manifestly a different problem from that of finding the island which is its extremity. The necessities of the first case are met by observing the appearance, development, and perhaps the decline of some important structure, such as a tooth. The line of natural succession is the important fact, and the classification, as far as there is any, is here of necessity artificial, touching at only one point, that of living forms, which lies in a distinct plane. It is only when considered with reference to their own horizons that fossil species are distinctly comparable to the specific islands of to-day; and to fail to consider the breaks in the horizontal series, because the vertical series is theoretically continuous, is one of the more important instances where a confusing element has been unnecessarily and illogically introduced. It is one task of taxonomy to recognize the facts of the present; and this need not be complicated, but should rather be assisted, by a knowledge of what has been or a suspicion of what may yet be. Nor is it necessary to be frightened by the captious warning that the species now existing will give place to something different to-morrow. The "now" is at least sufficiently extensive for our purposes. As to the coming change, posterity will not know its rate nor direction unless we certify the details of the present reality. The careful description and preservation of types, instead of works of supererogation, are of the utmost importance, not as means of specific limitation, but as giving fixed points about which accretions of knowledge may gather. The recognition and adequate designation of natural species or higher groups are frequently matters of extreme difficulty, requiring extended and careful study which the agnostic naturalist jauntily avoids, sometimes by professing interest in "more important" problems. To tell from a few specimens whether a new form represents a distinct species or not is frequently impossible, and opinion must be provisionally based on the analogy of better known relatives; but this initial difficulty in no way affects the practicability of the subsequent settlement of the question by more extended observation.

Whether the segregation of a new group has been accom-

plished seems to be a matter of indifference to some ultra-progressive naturalists. It is as though a geographer, having learned that a certain region is slowly subsiding, should proceed to name the hills as islands, and publish his book revised for the next geologic period. Such a procedure would be, to say the least, misleading, both for the present and future generations. This is the third type of "species," very much in evidence at the present day. Although the designation by name of the various prominences or arms of a diversified island is desirable, even before the expected separation occurs, the prophetic tendency should, in the interest of historical accuracy, be curbed to the extent of distinguishing in category between groups which are already segregated in nature and those which are not. One naturalist refers to an entire island as a species, while another divides it into numerous parts which he still calls "species." Now these parts may be as abundant in individuals, and their extremes may show differences even greater than those separating completely isolated species, but by treating them as already distinct we ignore the existence of intermediate forms and proceed as though degree of apparent difference were an index of segregation or a taxonomic substitute for it. The theory that the formation of species through differentiation and segregation is proceeding continuously throughout nature has too often served as a warrant for a complete confusion of issues, with the natural result that some writers have shown more frankness than perspicacity in assuming the position that species are among the things "past finding out."

As if to solidify the confusion and justify this attitude, the naturalist is called to deal with a rapidly increasing number of man-made perversions, or at least diversions of nature. We assemble from different continents species of undoubted distinctness and absolute segregation in nature, and produce hybrids which nature would never have formed and would not now permit to exist except under human auspices. Some natural species, too, have shown themselves wonderfully susceptible of change through the influence of selection, so that the honest advocate of a general specific concept finds himself under the

necessity of recognizing species and genera created by the gardener and poultry fancier. Taking as a criterion of amount the minute differences by which some distinctly segregated species, such as those of *Antennaria*, are distinguished, the impartial botanist of conceptual proclivities would find himself more than occupied in providing for the scientific recognition of horticultural novelties. With degree of difference as the criterion of classification, the annual increase in the species of the genus *Rosa* would be very considerable, for the divergences resulting from crosses and selection are often as great as those existing between wild species of undoubted validity.

The four types of species may then be enumerated as follows:

1. *The phylogenetic species, a division or section of a line of biological succession.*

2. *The insular or segregated species, the living end of a line of the preceding category.*

3. *The incipient species, preferably known as the subspecies,* which is a subdivision of the second category, being a group of individuals showing distinctive characters and a tendency to segregation, but still connected with other groups by normally existing intermediate forms.

4. *The artificial species, the result of man's interference in nature,* by which the specific islands of the second category have been, as it were, remodeled or connected by causeways or bridges, the natural tendency to isolation and segregation having been reversed through human agency.

In one case only does nature limit the species; in the other three the species are arbitrary in the sense that their boundaries are formal and to that extent conceptual. It were much better if other terms could be made available, so that the designation "species" might be reserved for its original use with the second category. For the third the appropriate term "subspecies" is increasing in favor, while to the fourth there seems to be no good reason why the popular designation "variety" should not be restricted. Even here it is not the absolute degree or amount of difference which determines the desirability of independent recognition for a new form, but the constancy and utility of the differences. It is fortunately still true that

the second category stands forth as by far the most important sense of the term "species," and much confusion and difficulty would have been avoided if it had been consistently restricted to that purpose. But equally loose has been the application of the subordinate designations "subspecies," "variety," "form," and "race." With "amount of difference" as the only criterion, fossils, geographic races, and artificially produced varieties are being catalogued miscellaneously and indiscriminately as "species."

After this failure to distinguish between the different tasks of taxonomy, it is not surprising that the total difficulties have been set forth with as complete an absence of discrimination. It is true, for instance, that some so-called species are arbitrary and artificial concepts, though it is equally true that other species are clearly defined assemblages of similar individuals, the case depending on how we make our terms and how we use them. But it is least certain that any method of procedure is faulty which tends to obscure the various issues and make confusion where none need exist. The limitations of our ignorance are already great enough without unnecessarily increasing them. A student of geography might conclude, after spending some time on the attempt, that it would not be worth while for him to write a monograph of the Florida Keys, but we would scarcely expect him to advertise his failure by composing a treatise to show that geography is an impossibility, since coast lines and landmarks are continually changing. The facts of nature are what we are trying to learn, not systems and concepts. These are, at best, but means, and we should change or throw them aside if they fail of their purpose, instead of allowing ourselves to become entangled in them. Let the term "species" be abandoned altogether, if by so doing we can better realize that the tasks of biological taxonomy are not one, but several, and that each should be approached to the greatest possible advantage without being gratuitously complicated. To trace lines of descent and be able to locate each individual in its proper place is a work quite distinct in plan and execution from the mapping of the islands of life as they lie in the sea of nonexistence. The topography of individual islands is

a subject of extreme interest, and it is perhaps even more important to record and make accessible all knowledge gained regarding the behavior of organized nature under the moulding hand of men. Many facts will have places in the treatment of all four problems, since these touch at many points; but from the standpoint of the execution of the work there is no logical necessity that any one task be rendered more difficult by the existence of the others. In dealing with each of the categories here enumerated, appropriate criteria of so-called species should be sought and persistently followed. If we are to continue to talk of geological or phylogenetic species, we must understand that they can, even in theory, be little more than arbitrary sections of the extinct lines of succession leading up to the living islands of the present, of which the number, form, and relative position can be satisfactorily determined only by directing attention to the question of segregation by space, time, or mutual sterility. To certify on simple inspection whether an individual specimen of a previously unknown plant represents a new species, a subspecies, or a hybrid, is, and must remain, impossible. Notwithstanding much eminent opinion to the contrary, we may insist that the facts of nature and not the concepts of the human mind are the primary objects of biologic study. In this instance, at least, we may rest assured that no refinement of concepts will enable us to know in advance facts which must be ascertained by careful and often by extended observation. The believers in the doctrine of "amount of difference" have, it is true, an apparent advantage in that by the simple application of their individual measuring rods they may be ready to assert, without the embarrassment of delay, that a new individual represents a new species, since it appears "sufficiently different" from others to meet the demands of their "conception of species." If these mental phenomena could be communicated with uniformity to other naturalists, the method would have a practical advantage which it does not now enjoy, since the conception is merely individual, and uniformity of opinion can never be expected. Segregation or its absence is, however, a fact of nature which may be established by careful observation, like other phenomena. If some systematists deny

this, they are but confessing that species are for them descriptions in books, not aggregates of similar individuals in nature. From the biological standpoint there could scarcely be more useless and unproductive labor than this of matching descriptions. The merits of a proposed species, that is, its normal segregation in nature, are not to be inferred from the formal description of a few individuals, and all so-called "species" established on such a basis are merely tentative propositions — suggestions for study. The question is not whether the description is different from all other descriptions, but whether the type specimen is, in reality, a member of an independent series of individuals, a distinct branch of life, a separate island of existence. The systematist is in no way responsible for the conditions; it is his business merely to recognize and record them. The difficulties vary greatly in different parts of nature, depending upon facts in the biology of the various groups. Thus the well-nigh inextricable confusion of the genus *Sphagnum* is undoubtedly connected with the fact that all the species have almost exactly the same position in the economy of nature, and affect the same habitat, while segregation has been further hindered or at least obscured by the absence of any natural period to the life of the individual plants. Remotely ancestral and all succeeding forms may still exist simultaneously and contiguously, affording a rare complication of difficulties. But in this case, as in others, we can best gain knowledge of the lines of divergence and learn something of the present tendencies of evolution by locating the breaks in the series of forms. The use of the term "species" may be a matter of indifference, but confusion in this formal regard should not be allowed to obscure the interest which attaches to the history and status of so isolated a group of plants.

Having once located and delimited our specific islands, the work of studying their internal topography is comparatively simple. The limitation of subspecific groups is necessarily arbitrary, but it need not be on that account artificial, the object of such subdivision being the recognition of tendencies toward segregation, rather than the formation of groups of uniform size. We are concerned, in other words, with the natural

features of our islands rather than with the number of farms or building lots into which they may be subdivided.

The fourth type of species may not appear logically distinct from the second and third, since natural hybrids occur, and have had, no doubt, their influence in evolution. From the practical standpoint, however, it may be maintained that the hybrid nature of a new form is not to be assumed without reason; and it is plain, in addition, that where we know the history and ancestry of a hybrid or selective variety, we should draw every possible advantage from that knowledge instead of undertaking the gratuitous labor of attempting a second and entirely artificial diagnosis. With domestic animals classification is carried to its ultimate extreme by means of carefully recorded pedigrees, while in the cultivated plants a similar refinement exists, particularly in the varieties of fruits which are propagated by grafting, the so-called variety being, in a sense, but a single individual, in spite of its extensive multiplication and distribution. Such classifications are not less scientific because they are also of practical utility, and the necessity of uniformity in the nomenclature of artificial varieties and hybrids is becoming a scientific as well as a popular necessity. At the same time it is extremely doubtful whether the desultory systematic methods of the past and present can supply such a desideratum. Any attempt at instituting an authoritative nomenclature of cultivated plants would need, in justice to the practical interests concerned, to be so equipped as to furnish prompt and accurate determinations, and to be able to incorporate into knowledge and provide names for all new varieties without loss of time. Such a plan once carried into execution would be of the greatest importance to agriculture, since it would render practicable the execution of laws which might be enacted to prevent the present enormous losses from falsely named and dishonestly advertised seeds and propagating stock.